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A FAILURE CLASS IN ALGEBRA

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In the autumn of 1917, the writer, a teacher of mathematics in Central High School of Kansas City, Missouri, was assigned a class in first-year algebra, composed of Sophomores, Juniors, and Seniors. These pupils had failed in algebra from one to three times before September, 1917. Such classes are not exceptional in large city high schools where algebra is required of all first-year pupils. In organizing their schools, principals must plan to take care of these pupils. Provisions for such classes require from one-fifth to three-fifths of one teacher's time. The waste of school funds in the maintenance of these classes is evident. Since these pupils are more difficult to teach than ordinary pupils, the vital strain on the teacher is evident. The economic waste in this situation deserves the special consideration of the school officials and the public. The waste of time of from thirty to ninety pupils for fifty minutes a day for ten school months a year is probably a more serious economic loss than that sustained in money and teacher energy combined.

Impressed by the seriousness of these losses, the writer, after consultation with Principal H. H. Holmes, determined, on the advice of Dr. W. W. Charters, to give the Binet-Simon tests for general intelligence, and the Rugg and Clark tests to disclose their specific trouble in algebra. Furthermore, by the advice of Principal Holmes, he gave the test for general intelligence to those pupils only who volunteered to take it. Inasmuch as the Rugg and Clark tests provide for measuring ability in the mechanics of the subject only, the writer decided to give three additional tests in reasoning. Accordingly, a set of tests, based upon the interpretation problems of the text (Hawkes-Luby-Touton's *First Course in Algebra*) were given as a gauge of the reasoning power of the pupils—a test of the pupil's ability to translate English into algebraic symbols.

After an explanation of the purposes of the intelligence tests, twenty-three out of a class of thirty-four volunteered to take it. Some pupils whose general appearance indicated a low degree of intelligence failed to volunteer. The Binet-Simon tests were administered as directed by Terman in his Stanford Revision, published by Houghton Mifflin Co., 1916. The Rugg and Clark tests were given as controlled tests and were made a portion of the regular daily recitations. The pupils were supplied with score cards and were enabled to compare their work with the standards that had been established by Rugg and Clark in their experiments. The reasoning tests were given in the same manner as the Rugg and Clark tests.

Furthermore, it was determined to get as much of the pupil's past history as possible. To attain this the questionnaire on the following page was submitted to each pupil. The questionnaire was answered in the homes of the majority.

On the whole the pupils answered all the questions with the exception of those that probably seemed to them too personal. If their parents were either high-school or college graduates, the children answered readily. We are compelled to assume in the cases where the parents were not high-school or college graduates that the pupils or parents considered the question too personal and did not answer. Questions as to the education of the entire family fared in the same manner, likewise the questions as to the home library and the magazines in the home. If the home was owned or a rental of $25 a month was paid, pupils answered. We must assume in the other cases that the home was not owned or that the rental paid was less than $25 a month. General appearance of the pupils as to dress, refinement of actions, and personal inquiry lead us to believe that each of the above assumptions is correct.

From the data at hand we find that 42.61 per cent of the class were girls and 57.39 per cent boys. The home environment for all was medium in all but five cases. The home surroundings of four of these could be classed as good and those of the fifth were distinctly bad.

All of the twenty-three pupils were American born. Eighteen of the twenty-three had both parents American born. Four had both parents foreign born and one had a foreign-born father. Just to what extent the ideals of the foreign-born parents conflicted with American ideals and to what extent the difference of ideas affected school progress is extremely hard to determine, because the conduct of these children was good. It is possible, but hardly probable, that the ideals may have affected the home-study programs of the pupils.

The affect of a foreign language in the home probably affected the school progress in the primary grades, but it is certain that the

QUESTIONNAIRE

ANSWER EACH QUESTION, IF AGREEABLE

Name..............................Address............................
Nationality...........................Name of father....................
Nationality of father..................Name of mother....................
Nationality of mother..................Language of father.................
Language of mother....................Language of home.................
Education of father....................Education of mother...............
Occupation of father...................Occupation of mother...............
Number of books in the home...........Number of magazines in the home....
What books do you read?..
What magazines do you read?..
Do your parents own their home?.......How much rent do you pay?.........
Age of walking.........................Age of talking......................
How often have you been seriously ill?.............When?.................
Did you fully recover?.................Are you in good health today?........
Number years attended ward school.....Number years attended high school...
Number grades repeated................Number grades skipped.............
Number subjects repeated..............What subjects repeated?.............
Number years you have studied algebra...Will you study geometry?...........
Will you study algebra 3?..............Will you study geometry 3?..........
Reason for your response..
What high-school subjects do you prefer?................................
Why?...
How many in your family?.............How many under 14 years old?.......
How many over 14 years old?...........Do you work after school?...........
How many of your brothers and sisters graduated from ward school?.............
How many of your brothers and sisters attended high school 1 year?.............
How many of your brothers and sisters attended high school 2 years?............
How many of your brothers and sisters attended high school 3 years?............
How many of your brothers and sisters attended high school 4 years?............
How many of your brothers and sisters attended college ½ year?................
How many of your brothers and sisters attended college 1 year?.................
How many of your brothers and sisters attended college 2 years?................
How many of your brothers and sisters attended college 3 years?................
How many of your brothers and sisters attended college 4 years?................
How many of your brothers and sisters stopped school at any time before they graduated from the school attended?..............In what year did they stop?...................Was it ward school, high school, or college?.......
Has mathematics always been difficult for the members of your family?..........
Did they tell you it was a difficult subject?.................................
Do they consider it a loss of time to study algebra?............................

DATA OBTAINED FROM QUESTIONNAIRES, CLASS GRADES, AND INTELLIGENCE QUOTIENTS

Pupil	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Sex	M	F	F	F	M	M	F	M	F	F	M	M	F	F	M	M	M	F	M	M	M	F	M
Home environment	M	G	M	M	M	M	M	M	M	M	P	M	G	G	M	M	G	M	M	M	M	M	M
Nationality of parents	A	A	A	A	I	H	A	A	A	A	A	A	A	A	H	A	A	A	H	A	A	A	A
Nationality of pupil	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Good health	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes
Defects in sight	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	No
Defects in hearing	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Adenoids	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	No
Bad tonsils	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	No
Years in high school	4	2	2	2	3	4	2	3	2	3	2	3	2	4	3	2	2	2	2	2	3	2	2
Grades repeated	1	1	0	0	2	1	0	3	0	0	½	0	0	1	0	0	0	0	1	1	1	2	2
Grades skipped	0	1	0	1	0	0	½	0	0	0	0	0	½	0	0	0	0	0	0	0	0	0	0
Language of home	E	E	E	E	I	Y	E	E	E	E	E	E	E	E	Y	E	E	E	Y	E	E	E	E
Chronological age	18–9	15	15–6	15–8	17–8	19–6	16–4	16–2	15–4	18–3	15–6	17–2	15–8	18–3	16	15–3	15	15–11	16	16–9	18–3	17–8	18–4
Mental age	18	16–1	16–1	16–2	16–4	16–1	15–11	15–11	14–10	15–2	14–5	14–11	14–8	14–11	14–9	14–10	14–4	14–3	14–1	14–2	13–6	13–2	12–2
Intelligence quotients	112	107	104	103	102	100–	100–	99	97	94	93	93–	93	93–	92	91	90	89	88	88	84	82	70
Class grades	65	75	75	65	65	75	65	65	85	65	55	55	65	75	65	65	65	65	65	55	55	55	55

A indicates American; H, Hebrew; I, Italian; Y, Yiddish; M, medium; G, good; E, English; P, poor; M, also indicates male; F, female pupils had overcome any language difficulties by this time. The use of the foreign language in the home could not in any manner have affected the general intelligence.

The conditions of the health of the pupils as set forth by responses to the questionnaire show that 13.04 per cent were not in good health at the time they were members of the class. Student M has suffered with spinal curvature from infancy and is compelled to wear a brace. Student R, in bad health, attended school very irregularly. However she said in the questionnaire that her health was good. Student U has lost one eye and suffers much with the other. Student V has suffered with eye defects and adenoids. Student W is in good health, but is clearly subnormal. W's mother visited the teacher and requested that W's intelligence be tested. She said, "I know that W is not like other children. I would take him from school if he were willing to quit. I am sending him hoping that he will get enough from his training to make him a good man and not a charge on the public."

Responses to the questionnaire show that with the exception of W none has failed in other high-school subjects. It would be interesting to compare the class grades in other subjects with their intelligence quotients and their grades in algebra.

Responses to the questionnaire show that each pupil taking the Binet-Simon test has failed once in algebra; that 60.88 per cent have failed once, 26.08 per cent have failed twice, and 13.94 per cent have failed three times prior to the school year of 1917–18. Responses further show that 52.08 per cent of the class have repeated grades during their ward school career; that 17.39 per cent have skipped grades, and that 30.53 per cent have gone through the ward school in a normal manner. It should be noted that one pupil who skipped one grade later repeated one grade; that two skipped one-half grade each, and another skipped a full grade, and that all three of these pupils completed their ward school course without demotion.

The teacher-marks in algebra for the year of 1917–18 were uniform, but higher than would have been given to an ordinary class upon the theory that it is better to hold pupils in school, to permit them to obtain social ideals from other subjects and make better citizens rather than to drive them from school by giving them failure-marks in algebra. A very large number were marked P meaning Poor as well as Pass.

A graphical comparison of the intelligence quotients of the boys and the girls of this class shows that the girls excelled the boys in general intelligence. (Intelligence quotient = mental age ÷ chronological age.) Comparison of the class grades of the boys and the girls shows that the girls again excelled the boys.

The writer computed the correlation coefficients between the intelligence quotients and the class grades by four different methods: graphic, Spearman's Foot rule, Spearman's "Rho" rule, and Pearson's fomula. Pearson's formula is the most accurate. In some few cases, Spearman's Foot rule was used to the exclusion of other methods in order to save time. In such cases the method of calculation is indicated.

The traits, intelligence quotients, and class grades were compared. The coefficient of correlation obtained by the graphic method was +.7225; by Spearman's Foot rule +.993; by Spearman's "Rho" rule +.6775; by Pearson's formula +.710. Each result from the above computations being positive, we conclude that there is a positive relation between the general intelligence of this class and the class grades assigned. That is, there is a positive relation between the algebraic ability of this class and their general intelligence. The median class grade was 68.8 per cent, 1.2 per cent below the ordinary passing grade of 70 per cent. The median intelligence quotient was 94.5, which is 4.5 higher than the lower limit of normal intelligence of any group of unselected individuals; it is also 5.5 below the lower limit of normal intelligence of high-school pupils, 15.5 below the upper limit of normal intelligence of any group of unselected individuals, and 25.5 below the upper limit of normal intelligence of high-school pupils.

It was further determined to compare the class grades and the intelligence quotients by computing the deviations from an arbitrary passing grade of 60 per cent and an arbitrary intelligence quotient of 90, the lower limit of normal intelligence of any group of unselected individuals. The result, a correlation coefficient of +.70 (Pearson's formula) signifies a positive relation between the class grades assigned and the general intelligence of this class when the deviations are computed from these arbitrary lower limits.

A similar comparison to that described above, with the exception that 100 was used for the arbitrary limit for intelligence quotients, from which deviations of the intelligence quotients were computed, resulted in a correlation coefficient of +.71 (Pearson's formula), signifying a positive relation between the class grades and the general intelligence of the class.

A comparison of the intelligence quotients and the marks made in the Rugg and Clark Test No. 1 resulted in a correlation coefficient of +.882 (Spearman's Foot rule). This test consists of collecting of monomials. The class standard was 9.15 right in three minutes while the Rugg and Clark standard was 12 right in three minutes. This class had gone over the principles involved from two to four times, the number of times varying with the individual students, prior to taking this test.

A comparison of the arithmetic means of all the marks made in the sixteen Rugg and Clark tests and the intelligence quotients resulted in a correlation coefficient of +.998 (Spearman's Foot rule).

A comparison of the arithmetic means of the reasoning tests and the intelligence quotients resulted in a correlation coefficient of +.753 (Spearman's Foot rule).

A comparison of the teacher-marks and the arithmetic means of the Rugg and Clark tests resulted in a correlation coefficient of .999 (Spearman's Foot rule). The class grades were not based upon results of the tests. If the Rugg and Clark tests are trustworthy, then the teacher-marks are absolutely reliable as a gauge of the algebraic ability of this class.

A comparison of the arithmetic means of the reasoning tests and the arithmetic means of the sixteen Rugg and Clark tests resulted in a correlation coefficient of +.979 (Spearman's Foot rule). The conclusion is, if the Rugg and Clark tests are a true measure of the mechanical ability of the class in algebra, then, the reasoning tests are perfectly reliable as a measure of the reasoning powers of the class in interpretation problems.

It was further determined to test the reliability of the correlation coefficient, +.71 (computed by Pearson's formula), by applying the formula accepted by Rugg and by Thorndike as a necessary and sufficient test of the trustworthiness of such computations. Applying the formula and interpolating and using the tables on page 404 of Rugg's *Statistical Methods in Education*, we obtain a probable error of .0717. This indicates that the calculation of this correlation coefficient +.71 is reliable to seven hundred seven ten thousandths of a unit.

The writer accepts the Rugg and Clark tests as the best method of testing the pupils in the mechanical processes of first-year algebra that he has seen. They have been worked out scientifically, and are reported in a monograph entitled, "Scientific Method in the Reconstruction of Ninth-Grade Mathematics," published by the University of Chicago. He furthermore accepts the Stanford Revision of the Binet-Simon tests for intelligence as the best test for intelligence at the time this study was made.

The correlation coefficient produced by comparing the class grades and the intelligence quotients shows that this class was subnormal in algebraic ability.

The correlation coefficient produced by comparing the arithmetic means of the sixteen Rugg and Clark tests and the intelligence quotients shows that this class was distinctly subnormal in algebraic ability.

The writer, despite the class records in other subjects, when he views the results of the several tests and the correlation coefficients resulting from comparing the data obtained from these tests, believes that this class as a whole is subnormal in general intelligence.

This study further shows that there is a fundamental relation existing between failures and repetition in algebra, and a low grade of intelligence as shown between the high correlations between these two traits.

We conclude that these classes are maintained at a waste of public-school funds. For this reason they should be eliminated. These classes are maintained at a great cost of teacher-vital-energy and for that reason should be eliminated; these classes are maintained at a great loss of the pupils' time and should be eliminated to save economic waste. Since there is a close relation between general intelligence and ability to learn algebra, it seems reasonable to conclude that the general intelligence of each pupil should be determined before he is required to take the subject. If he is clearly below normal in general intelligence, he should be prohibited from taking algebra unless there should be good reasons to the contrary. Since the United States government accepted psychological tests as a basis for the classification of men in the army and the indications are that the classification on this basis was a success, it seems probable that the schools will eventually try to determine the general intelligence of the pupils and make the results obtained the basis of classification in all subjects.

ARITHMETIC MEANS OF THE DATA OBTAINED FROM THE RUGG AND CLARK TESTS AND THE REASONING TESTS

Pupil	Rugg and Clark	Reasoning
A	11.5	5.6
B	11.6	6.1
C	9.5	3.5
D	10.0	5.2
E	11.2	5.6
F	8.6	4.0
G	7.4	4.4
H	9.5	3.6
I	9.9	3.8
J	10.8	5.2
K	8.8	4.1
L	6.4	2.5
M	8.2	3.8
N	9.1	4.2
O	8.8	5.3
P	9.3	5.1
Q	8.8	4.0
R	8.0	2.4
S	8.9	3.6
T	3.6	1.3
U	3.5	2.5
V	5.7	2.1
W	6.2	3.0